### **Coronal Mass Ejections**

A dissertation submitted to the University of Dublin for the degree of  $Philosophiæ\ Doctor\ (PhD)$ 

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> SCHOOL OF PHYSICS UNIVERSITY OF DUBLIN TRINITY COLLEGE



#### Declaration

I declare that this thesis has not been submitted as an exercise for a degree at this or any other university and it is entirely my own work.

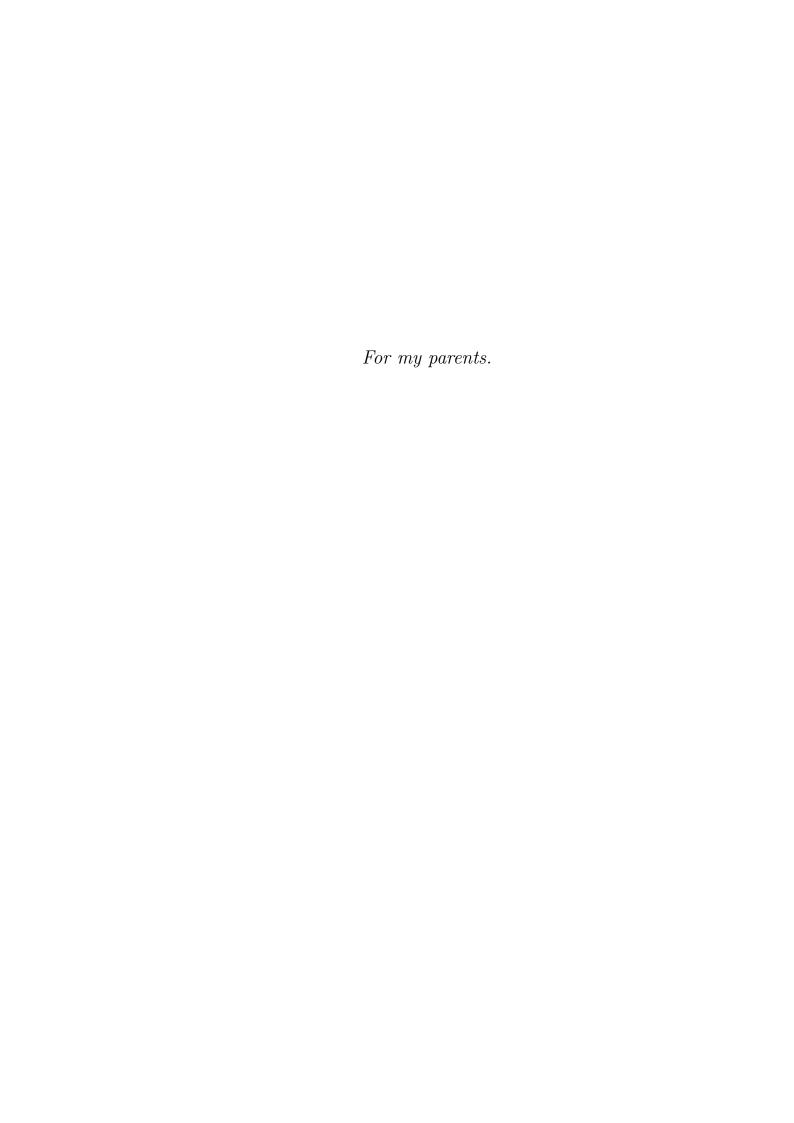
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#### Summary

Coronal mass ejections (CMEs) are large-scale eruptions of magnetized plasma from the low solar atmosphere into interplanetary space. With energies of up to  $10^{26}$  J, they are the most energetic eruptive phenomena in the solar system and are also the driver of radio-bright plasma shocks from the corona into the heliosphere. However, the nature of the forces governing their eruption, and how this eruption drives a radio bright shock, is poorly understood.



#### ${\bf Acknowledgements}$

Some sincere acknowledgements...  $\,$ 

#### List of Publications

- Carley, E. P., MacAteer, R. T. J., & Gallagher, P. T.
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  Some Journal, Volume X, Issue Y, article id. (2013)
- Bloomfield, S. D., Carley, E. P.,
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# Introduction

The Sun has long been the focus of humanity's curiosity. Throughout history it has been the harbinger of new religions, philosophies, and sciences. It has changed our understanding of our place in the Universe and allowed us to push forward the frontiers of physical science. Although our understanding of the Sun is nowadays more advanced, the curiosity we hold for it has not changed since the very early humans. Now, we understand the Sun is a star similar to any other in its class, currently going through a relatively unchanging 11 year cycle of activity from solar minimum to solar maximum and back again. Most of the phenomena described here result mainly from the energetic processes occurring during solar activity maximum.

- 1.1 The Sun
- 1.1.1 Solar Interior
- 1.1.2 Solar Dynamo and Magnetic Field
- 1.1.3 Solar Atmosphere
- 1.1.4 Solar Wind
- 1.2 Coronal Mass Ejections and Coronal Shocks
- 1.2.1 Observations
- 1.2.2 Current understanding
- 1.2.3 Open Questions

# 2

# Magnetohydrodynamic and Plasma Kinetic Theory

- 2.1 Magnetohydrodynamics
- 2.1.1 Magnetic Reconnection
- 2.1.2 Coronal Mass Ejections
- 2.1.3 Coronal Shocks
- 2.2 Plasma Kinetics
- 2.2.1 Boltzmann Equation
- 2.2.2 Shock Particle Acceleration
- 2.2.3 Wave-Particle Interaction
- 2.2.4 Electromagnetic Radiation in Plasma Shocks



This is where the appendix would go...

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